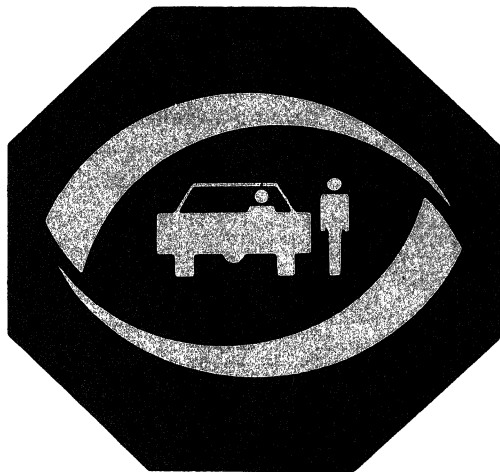


712 An Announcement of Recent Acquisitions. . .

**HSL No. 71-9
March 5, 1971**



THIS ISSUE CONTAINS:

HS-008 620 - HS-008 667
HS-800 322 & HS-800 323

HSL No. 71-9 March 5, 1971 HS-008 620 - HS-008 667, HS-800 322 & HS-800 323

INTRODUCTION

Publications announced in *Highway Safety Literature* include the most recent additions to the collection of the NHTSA Scientific & Technical Information Service. Subject areas covered include all phases of highway, motor vehicle, and traffic safety, especially those encompassed by the National Traffic and Motor Vehicle Safety Act of 1966 and the Highway Safety Act of 1966.

Individual issues of *HSL* are numbered according to the year and the issue number within that year; thus, 71 designates the year and 1, 2, 3, etc. the individual issues. To aid the user in location citations by the HS-number, the cover bears the inclusive entry numbers for each issue.

Entries in *HSL* are arranged according to the revised NHTSA Subject Category List shown in the Table of Contents. The List is a two-level arrangement consisting of five major subject fields subdivided into 58 subject groups. Documents related directly to the National Highway Traffic Safety

Administration (NHTSA) are announced in a separate section headed NHTSA DOCUMENTS and are numbered in five distinct series: NHTSA Accident Investigation Reports (HS-600 000 series), NHTSA Compliance Test Reports (HS-610 000 series), NHTSA Contractors Reports (HS-800 000 series), NHTSA Staff Speeches, Papers, etc. (HS-810 000 series), and NHTSA Imprints (HS-820 000 series). For NHTSA DOCUMENTS in series HS-600 000 and HS-610 000, individual full case reports are available for inspection at the National Highway Traffic Safety Administration; or for purchase from NTIS (see page ii). Although announced together in a separate section, these documents are also assigned specific subject categories for machine retrieval.

A document which contains a number of separate articles is announced as a complete volume in the subject category most applicable to it as a whole. Entries for the individual articles appear in their most specific subject category.

SAMPLE ENTRIES

Subject Category Array _____
NHTSA Accession no..... HS-800 218 Fld. 5/21; 5/9
Title of document..... AN INVESTIGATION OF USED CAR SAFETY STANDARDS--SAFETY INDEX: FINAL REPORT. VOL. 6 - APPENDICES G-L
Personal author(s)..... by E. N. Wells; J. P. Fitzmaurice; C. E. Guillems; S. R. Kalin; P. D. Williams
Corporate author..... Operations Research, Inc., Silver Spring, Md., 015000
Collation _____
Publication date..... 12 Sep 1969 150p
Contract FH-11-6921
Report no. ORI-TR-553-Vol-6; PB-190 523
Abstract..... Appendices G-L to this study of used car safety standards include: indenture model diagrams for classes I-IV motor trucks; degradation, wear, and failure data for motor truck classes I-IV; and safety index tables for classes I-IV motor trucks.

Search terms: Wear /Trucks;
Failures /Trucks; Used cars; Inspection standards /Trucks; Inspection standards /Data

HS-004 497 Fld. 5/19

AUTO THEFT THE PROBLEM AND THE CHALLENGE

by Thomas A. Williams, Sr.

Journal citation . . . Published in *FBI Law Enforcement Bulletin* v37 n12 p15-7 (Dec 1968)

Gives figures on the extent of the auto theft problem and comments on antitheft devices available now or in the planning stage.

Search terms: Theft, Theft protection, Stolen cars

AVAILABILITY: NTIS

TABLE OF CONTENTS

NOTE: () Numbers in parentheses following certain subject groups indicate the Highway Safety Program Standards (No. 1, and up) and/or Federal Motor Vehicle Safety Standards (No. 101 and up) which may apply to these groups.

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NOTE: Material published in Highway Safety Literature (HSL) is intended for the information and assistance of the motor vehicle and highway safety community. While brands names, equipment model names and identification, and companies may be mentioned from time to time, this data is included as an information service. Inclusion of this information in the HSL should not, under any circumstances, be construed as an endorsement or an approval by the National Highway Traffic Safety Administration, Department of Transportation of any particular product, course, or equipment.

Harry A. Feinberg
Managing Editor

AVAILABILITY OF DOCUMENTS AND INSTRUCTIONS FOR ORDERING

Department of Transportation personnel may borrow copies of publications directly from the NHTSA. Outside the Washington, D.C. area, phone (202) 426-2768. In Washington, D.C. area, use government ID, phone 118-62768. Non-DOT personnel should contact their company or agency libraries for assistance.

Journals cited may be obtained through most research libraries.

Contractors' reports and other documents can usually be obtained as indicated under AVAILABILITY. However, there is no certainty that retention copies will be available for more than a limited period after a document is issued.

The more common distribution sources are identified by symbols which are explained below:

NTIS: National Technical Information Service (formerly Clearinghouse for Federal Scientific and Technical Information-CFSTI), Springfield, Va. 22151. Order by accession number: *HS, AD, or PB*. Prepayment is required by NTIS (CFSTI) coupon (GPO coupons are not acceptable), check, or money order (made payable to the NTIS). PC (Paper copy; full size original or reduced

facsimile) \$3.00 up; *MF* (microfiche approximately 4x6" negative sheet film; reader required) \$0.95.

GPO: Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Give corporate author, title, personal author, and report number. Prepayment is required by GPO coupon (NTIS [CFSTI] coupons are not acceptable), check or money order (made payable to the Superintendent of Documents).

HRB: Highway Research Board, National Academy of Sciences, 2101 Constitution Ave., N. W., Washington, D. C. 20418.

NHTSA: National Highway Traffic Safety Administration General Services Division, Washington, D.C. 20591 (Telephone (202) 426-0874).

SAE: Society of Automotive Engineers, Dept. HSI-1, 2 Pennsylvania Plaza, New York, N.Y. 10001. Order by SAE report number. Prices given are list; discounts are available to members and sometimes to libraries and U.S. Government Agencies. Prepayment is required; orders without payment are subject to a \$1 handling charge.

IMPORTANT

WHEN REQUESTING a document, to be absolutely sure you receive what you order, give the accession number (HS, PB, AD number) or report number (in cases such as an SAE document), title of report, and the personal or corporate author (whichever is cited). When requesting an HS-numbered document from NTIS (CFSTI), add DOT/ to the prefix HS-; example HS-800 000 should be ordered as DOT/HS-800 000.

SPECIAL NOTICE

NEW PRICES FOR DOCUMENTS AVAILABLE FROM NTIS

On January 1, 1971, the National Technical Information Service (NTIS) increased the prices for documents in certain categories. These increases were made necessary by increased costs. Prices are now as follows:

PAPER COPY

Most documents announced after January 1, 1969, are priced:

1 to 300 pages	\$3.00
301 to 600 pages	6.00
601 to 900 pages	9.00
Over 900 pages	Exception Price

Two years after announcement, documents having 300 pages or less will have a service charge of \$3.00 added to the announced price. No service charge will be added for documents over 300 pages.

Documents announced prior to January 1, 1969, have a service charge of \$3.00 added to the announced price.

MICROFICHE

Microfiche reproduction of documents on a demand basis are priced at 95 cents per document.

Documents available on Standing Order through NTIS Selective Dissemination of

THE EFFECTS OF ACUTE VENTRICULAR TRAUMA

by Thomas B. Quigley

Harvard Medical School, Boston, Mass., H04200

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p399-401

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Vehicular trauma is discussed as a disease. The doctor's role in prevention and management is discussed.

Search terms: Accidents/Injuries; Physicians and highway safety

AVAILABILITY: In HS-008 628

HS-008 621 Fld. 1/3

THE DYSCONTROL SYNDROME: A LOOK AT AUTO ACCIDENTS AS A MEDICAL DISEASE

by Vernon H. Mark; William Sweet; Frank Ervin

Boston, City Hospital, Mass., B22000

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p397-8

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Because of the unusual and persistent findings of dangerous driving in patients with limbic brain disease, the authors feel that the function of the limbic brain may be an important area of investigation for potential drivers. What percentage of dangerous drivers fall into this category of patients with poor impulse control is not known at the present time. The necessity for developing tests to assess limbic brain function is obvious. Tests are needed to detect poor impulse control before rather than after an accident because limbic brain disease is potentially

causes: Impulsiveness/Accident causes; Limbic system diseases/Accident causes

AVAILABILITY: In HS-008 628

HS-008 622 Fld. 1/3

SERIOUS EYE INJURIES PRODUCED BY WINDSHIELD DAMAGE—AN ACTUAL PROBLEM IN OPHTHALMOLOGY

by K. Müller-Jensen; W. Hollweck

Munich Univ. (West Germany), M66600

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p388-96

22 refs

Report no. SAE-700912

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich 17-18 Nov 1970.

Eye injuries resulting from broken windshields are very frequent. The mechanism of such accidents reveals that the head of the passenger, about 0.1 sec after the crash, is thrown against the inner face of the windshield with a relative speed corresponding to the collision speed within a range of 60 km/hr. It often happens that the skull penetrates single-sheet safety glass, which is found in 95% of German vehicles. In these cases the eye region falls toward the lower breaking zone of the windshield, which leads to a very characteristic, often absolutely horizontal line of injury. Over a period of five years, of the 240 patients observed in the University Eye Hospital in Munich, 62 patients (26%) suffered bilateral eye injuries due to windshield particles. In practically all cases, lacerations and cuts of the eyelids were observed. In 65% of the cases, serious lacerations of the corneal scleral border of the eye bulb—affecting the lens, vitreous, and retina—were present. These perforating

or less were eliminated.

Search terms: Eye injuries/Windshields; Occupant kinematics/Eye injuries; Ophthalmology/Windshield caused injuries; Windshield caused injuries/Blindness; Medical case reports/Eye injuries; Three point restraint systems/Injury prevention; Laminated glass/Injury prevention; Windshield caused injuries/Germany

AVAILABILITY: In HS-008 628

HS-008 623 Fld. 1/3

EVALUATION OF IMPACT TEST ACCELERATIONS: A DAMAGE INDEX FOR THE HEAD AND TORSO

by J. Brinn; S. E. Staffeld

Chrysler Corp, Detroit, Mich., C42600

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p188-220

18 refs

Report no. SAE-700902

This paper discusses a damage index which is believed to be superior to the current Severity Index in several respects. It employs a spring-mass model of the particular human organ under consideration; the input pulse is used as the forcing function and the displacement of the organ is calculated. This organ displacement is used as the parameter of damage. The displacement limit is set by employing input pulses which are known to approach the human tolerance limit. The analysis presented in this paper indicated that the displacements calculated in this manner are not overly sensitive to small errors in the determination of spring-mass values; thus the basic biomechanical data need not be highly refined. Future medical progress will ultimately determine the true suitability of this proposed index. It is felt, however, to be the most realistic basis for appraisals based on current knowledge.

1/3 Investigation and Records (Cont'd)

HS-008 623 (Cont'd)

Search terms: Acceleration tolerances; Decelerations tolerances; Human body impact tolerances/Injury severity index; Brain injuries/Impact tests; Head forms/Impact tests; Chest injuries/Impact tests

AVAILABILITY: In HS-008 628

HS-008 624 Fld. 1/3

TESTING THE VALIDITY AND LIMITATIONS OF THE SEVERITY INDEX

by V. R. Hodgson; L. M. Thomas: P. Prasad

Wayne State Univ., Detroit, Mich., W09600

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p169-87

16 refs
Report no. SAE-700901

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

The head acceleration pulses obtained from monkey concussion, cadaver skull fracture ($t = 0.002$ sec), and football helmet experiments ($0.006 < t < 0.011$ sec) have been subjected to injury hazard assessment by the Severity Index method. Although not directly applicable, the method correlates well with degree of monkey concussion. The range of Severity Indices for acceleration pulses obtained during impact to nine cadavers, all of which produced a linear fracture, was 540-1760 (1000 is danger to life) with a median value of 910. The helmet experiments showed good correlation between the Severity Index and the Wayne State University tolerance curve. These helmet tests also showed that a kinematics chart with curves of velocity change, stopping distance, average head acceleration, and time, with a superimposed Wayne

State tolerance curve, can be useful in injury assessment.

The Vienna mathematical model of Slatenschoek and Tauffkirchen proposed as an alternative method of hazard assessment to the Severity Index was tested with the football helmet data. Displacement response of the model increases relative to severity of impact and is in good agreement with predictions by the authors. It is shown that the Severity Index method does not apply to a metal head form.

Search terms: Injury severity index/Validation; Injury severity index/Mathematical models; Impact tests/Helmets; Acceleration tolerances/Head injuries; Impact tests/Cadavers; Impact tests/Monkeys; Impact tests/Head forms

AVAILABILITY: In HS-008 628

HS-008 625 Fld. 1/3

INTRACRANIAL PRESSURE AND HEAD ACCELERATION DURING WHIPLASH

by Harold D. Portnoy; Durand Benjamin; Michael Brian; Lowell E. McCoy; Bruce Pince; Robert Edgerton; Joseph Young

Federal Aviation Agency, Washington, D. C., F04200; Oakland Univ., Rochester, Mich., O00300; Space/Defense Corp., Birmingham, Mich., S33900; Pontiac General Hospital, Mich., P29250

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, Ann Arbor, Mich., 17-18 1970, p152-9

24 refs
Report no. SAE-700900

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Baboons were whiplashed to measure intracranial pressure (ICP) in whiplash, to correlate ICP to linear and angular head acceleration, and to determine if head restraint configuration altered ICP. Clinical, biochemical, physiological, and pathological observations were made.

Intracranial pressure increases in whiplashed baboons, and is temporally related to translational and rotational

head accelerations. With different head restraint configurations, the pressure increases are smallest when using a vertical restraint minimizing head movement, and are not reduced by partial restraints. There may be some correlation between EEG, clinical, and gross pathologic observations and the use of the various restraints, but EKG, heart rate, and biochemical measurements were not significant.

Search terms: Whiplash injuries/Animal experiments; Head restraints/Injury severity; Acceleration tolerances/Intracranial pressure; Brain injuries/Baboons; Electroencephalography/Impact tests

AVAILABILITY: In HS-008 628

HS-008 626 Fld. 1/3

PROTECTION FROM BRAIN INJURY: THE RELATIVE SIGNIFICANCE OF TRANSLATIONAL AND ROTATIONAL MOTIONS OF THE HEAD AFTER IMPACT

by Arthur E. Hirsch; Ayub K. Ommaya

National Highway Safety Bureau, Washington, D. C., N18000

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p144-51

8 refs
Report no. SAE-700899

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

The rotational and translational rigid body motions of the head after impact were evaluated by high-speed cinematography in Rhesus monkeys with and without a cervical collar. When a collar was worn, animals displayed increased tolerance to occipital impact for the onset of cerebral concussion. Although head rotations were reduced in this nonconcussed protected group, translational motion of the head exceeded that attained by concussed monkeys not wearing collars but struck at equivalent impulse levels. These data emphasize the inadequacy of current head impact tolerance criteria which relate the occurrence of brain injury to translational head motions.

injuries/Monkeys; Head restraints/
Injury severity; Brain injuries/
Impact tests

AVAILABILITY: In HS-008 628

HS-008 627 Fld. 1/3

THE REDUCTION OF COLLISION INJURIES: PAST, PRESENT, AND FUTURE

by Alan M. Nahum; Arnold W. Siegel; Samuel Brooks

California Univ., Los Angeles. Vehicular Trauma Group, C21600

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p1-43

9 refs

Report no. SAE-700895

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

The paper represents a distillation and analysis of collision injury cases collected by the UCLA Trauma Research Group from 1960-1969. Injuries are interpreted with relation to specific variables which are thought to represent important factors in collision injury causation and prevention. The methodology is presented as one possible way to view transportation trauma in terms of factors which can be isolated and may lend themselves to manipulation in the cause of traffic safety.

Search terms: Injury severity / Drivers; Injury prevention; Injuries / Regression analysis; Injuries / Mathematical models; Injuries / Statistical analysis; Injury research / Variables; Injury causes; Injuries by body area; Injury severity / Seat position

AVAILABILITY: In HS-008 628

HS-008 628 Fld. 1/3

PROCEEDINGS OF FOURTEENTH STAPP CAR CRASH CONFERENCE, November 17-18, 1970. Ann Arbor, Michigan

Published by: Society of Automotive Engineers, New York
1970 410p 317 refs

Sponsored by: The University of Michigan, Highway Safety Research Institute and Extension Service; University of California, Los Angeles; Biomechanics Research Center, Wayne State University.

Papers presented at this conference discuss injury prevention, restraint systems, motorcycle collisions, whip-lash injuries, injury severity indices, body simulation, windshield injuries, and impact tests including some using animals. Epidemiology of vehicle accidents was considered.

Search terms: Collisions / Conferences; Injury prevention; Restraint systems; Motorcycle accidents; Animal experiments / Impact tests; Whiplash injuries; Injury severity index; Human body simulation; Windshield caused injuries; Accidents / Epidemiology

AVAILABILITY: Includes HS-008 620-7, 008 629-30; 008 632-7; 008 653-6; 008 660.

HS-008 629 Fld. 1/3; 5/3

MOTORCYCLE COLLISION EXPERIMENTS

by Derwyn M. Severy; Harrison M. Brink; David M. Blaisdell

California Univ., Los Angeles. Inst. of Transportation and Traffic Engineering, C21000

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p66-120

10 refs

Report no. SAE-700897

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Seven collision experiments were conducted, each with a motorcycle and rider striking the side of a passenger car. Speed at impact, size of motorcycle, and position impacted along the side of the passenger car represent the

motorcycle collisions is described, along with related methodology. Photographic and electronic instrumentation systems were used for obtaining essential engineering data.

Search terms: Motorcycle accidents / Simulation; Motorcycle accidents / Impact tests; Motorcycle accidents / Human body simulation; Automobiles / Side impact collisions

AVAILABILITY: In HS-008 628

HS-008 630 Fld. 1/3; 5/14

BIOMECHANICS OF THE VERTEBRAL COLUMN AND INTERNAL ORGAN RESPONSE TO SEATED SPINAL IMPACT IN THE RHESUS MONKEY (MACACA MULATTA)

by L. E. Kazarian; J. W. Hahn; H. E. von Gierke

Aerospace Medical Research Lab. (6570th), Wright-Patterson AFB, Ohio, A10300

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p121-43

42 refs

Report no. SAE-700898

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Rhesus monkeys were anesthetized; radiographed; restrained by lap belt, torso harness, and limb retention straps; positioned in an impact carriage; and exposed to +G_z seated rectangular acceleration-time histories from predetermined drop heights. The shock programmer used throughout these experiments was aluminum honeycomb. Pulse accelerations ranged 25-900 G and total time duration 2-22 ms. Shortly after impact, all primates were radiographed, killed, and a necropsy performed. Attempts were made to determine injury potential as a function of plateau acceleration and pulse duration for various target organs. Spinal injury data support previous results and theoretical considerations that there are two distinct injury potential regimes; one, for which the velocity change is the determining physical parameter, and the

1/3 Investigation and Records (Cont'd)

HS-008 630 (Cont'd)

other for which peak g is the determining factor. Injuries observed in parenchymatous organs included external and surface hemorrhaging in the liver, lesions of the lung, and cardiac lesions. Their severity ranged from minor reversible abrasions to lethal trauma. These experiments strengthened confidence in the applicability of animal experiments to the quantitative explanation of human injury and to the extrapolation of animal results—after the application of the proper scaling factors—to human situations.

Search terms: Restraint systems / Animal experiments; Monkeys / Impact tests; Impact tests / Biomechanics; Acceleration tolerances / Abdominal injuries; Acceleration tolerances / Spinal injuries

AVAILABILITY: In HS-008 628

2/0 HIGHWAY SAFETY

2/9 Traffic Control

HS-008 631 Flid. 2/9

PROVEN WAYS TO REDUCE CONGESTION

by Alger F. Malo

1970 12p

Report no. SAE-700190

Presented at Automotive Engineering Congress, Detroit, Mich., 12-16 Jan 1970.

Detroit uses many traffic engineering techniques and methods to reduce congestion and speed traffic flow. Success is most frequently obtained by use of a mix of methods on a single street. Streets have been widened and laned, traffic channeled with left turns restricted or prohibited, parking prohibited, and a flexible progressive signal system devised to accommodate heavy peak flow. Freeways are the

capacity and have reduced congestion of many surface streets. Where congestion still exists, it is because funds are not available to apply the proper remedies.

Search terms: Traffic congestion / Detroit; Traffic flow / Detroit; Traffic engineering / Detroit; Traffic lanes; Left turns; Parking prohibitions; Traffic signals; Traffic capacity; Freeways; Street maintenance / Detroit; Highway improvements / Detroit

AVAILABILITY: SAE

3/0 HUMAN FACTORS

HS-008 632 Flid. 3/0

OF MEN AND MACHINES

by John P. Stapp

National Highway Safety Bureau, Washington, D. C., N18000

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p402-6

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Warnings regarding insatiable machines are presented. Among these machines are war machines, TV, computers, and transportation equipment, especially automobiles.

Search terms: Sociological factors / Transportation; Sociological factors / Computers; Sociological factors / Television; Sociological factors / Warfare

AVAILABILITY: In HS-008 628

3/2 Anthropomorphic Data

HS-008 633 Flid. 3/2

TOLERANCE AND PROPERTIES OF SUPERFICIAL SOFT TISSUE TISSUES IN SITU

by Charles W. Gadd; Alan M. Nahum; Dennis C. Schneider; Richard G. Maderia

General Motors Research Labs., War-

Los Angeles. School of Medicine, C21600

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p356-68

5 refs

Report no. SAE-700910

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Utilizing unembalmed cadaver test subjects, a series of tests was carried out to characterize quantitatively the resistance of the skin, the soft underlying tissue of the scalp, and certain other typical areas of the body to impact loading. The impacts were delivered by the use of an instrumented free-fall device similar to that previously employed for facial bone fracture experiments. In one group of tests, metal and glass edges were affixed to the impacting device to produce localized trauma under conditions which were standardized with respect to variables affecting the degree of the injury. In the second group of experiments, specimens of skin, together with underlying tissue of uniform thickness, were subjected to compressive impact between the parallel surfaces of the impacting weight and a heavy metal platen. From these latter experiments the force-time histories, coefficient of restitution, and hysteresis loops of load versus deflection were obtained for the specimens. It is suggested that the data obtained should be applicable to the evaluation of soft tissue injury hazard in accidents and to the appraisal of artificial soft tissue simulations for impact headforms and anthropometric dummies.

Search terms: Cadavers / Impact tests; Skin / Impact tests; Scalp / Impact tests; Cadavers / Impact tolerances; Skin / Anthropometric dummies; Scalp / Head forms; Skin / Hysteresis; Scalp / Hysteresis

AVAILABILITY: In HS-008 628

HS-008 634 Flid. 3/2

FRACTURE BEHAVIOR OF THE SKULL FRONTAL BONE AGAINST

by Voigt R. Hodgson; Jule Brinn; L. M. Thomas; S. W. Greenberg

Wayne State Univ., Detroit, Mich., W09600; Chrysler Corp., Detroit, Mich., C42600

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p341-55

6 refs

Report no. SAE-700909

A test program has been conducted to determine the fracture behavior of the human frontal bone against two different rigid cylindrical surfaces; one surface was of 1 in. radius and one was of 5/16 in. radius; both were 6 1/2 in. long. The purpose of this research program was to provide human tolerance data which would:

1. Assist in the design of structures likely to be impacted by the human head.

2. Extend the calibration range of fragile headforms.

Twelve cadavers were tested in this program; seven against the 1 in. radius cylinder and five against the 5/16 in. radius cylinder. The test arrangement employed a guided drop of the test surface against a stationary head which was free to rebound. Drop heights were increased progressively until borderline fractures were obtained.

Search terms: Cadavers /Skull fractures; Headforms /Impact tests; Impact tests /Structural design

AVAILABILITY: In HS-008 628

HS-008 635 Fld. 3/2

THIRD GENERATION OF AUTOMOTIVE TEST DUMMIES

by Peter I. Mate; Leonard E. Popp

Sierra Engineering Co., Sierra Madre, Calif., S17000

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p329-40

7 refs

Report no. SAE-700908

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

To meet today's demands for a higher degree of accuracy and repeatability in

automotive crash testing, a new advanced anthropometric dummy is under development.

This third-generation test dummy is designed to be in a 90 deg seated position and complies with all requirements of present SAE J963 specifications.

The head is a completely new design. The skull, which is covered with a removable skin, is symmetrical for better test repeatability. The newly developed neck concept produces more human-like response. New materials used in the neck and the lower vertebrae eliminate ringing effects. The new shoulder assembly features better contour and muscle tone, and withstands the expected shoulder harness loads. The chest of the previous generation dummies is replaced with a plastic contoured rib cage of the required load deflection characteristics. To provide a better means of restraint system evaluation, the new pelvis is human-like in contour. For better simulation of muscle tone, more reliable friction setting of joints is included.

Finally, for easier handling, the skin closure zippers are located in the rear and paddings are secured in place.

Search terms: Anthropometric dummies /Specifications

AVAILABILITY: In HS-008 628

HS-008 636 Fld. 3/2

PREDICTIONS OF MATHEMATICAL MODELS COMPARED WITH IMPACT SLED TEST RESULTS USING ANTHROPOMETRIC DUMMIES

by D. H. Robbins; R. O. Bennett; A. W. Henke; N. N. Alem

Michigan Univ., Ann Arbor, Highway Safety Research Institute, M40800

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p299-328

8 refs

Report no. SAE-700907

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-19 Nov 1970.

Mathematical models of the human body subjected to an impact environment have been developed by many

research groups in industry, government, private research organizations, and universities. In most cases, the models have not been verified by or compared with experimental results. The purpose of this paper is to show comparisons between the two- and three-dimensional crash victim simulators, which have been developed at the Highway Safety Research Institute of The University of Michigan, and front and side impact sled test results using anthropometric dummies.

Search terms: Human body impact tolerances /Mathematical models; Anthropometric dummies /Impact tolerances; Human body impact tolerances /Validation; Impact sleds /Tests

AVAILABILITY: In HS-008 628

HS-008 637 Fld. 3/2

DEVELOPMENT OF A MECHANICAL MODEL OF THE HUMAN HEAD--DETERMINATION OF TISSUE PROPERTIES AND SYNTHETIC SUBSTITUTE MATERIALS

by J. W. Melvin; J. H. McElhaney; V. L. Roberts

Michigan Univ., Ann Arbor, Highway Safety Research Inst., M40800

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p221-40

9 refs

Report no. SAE-700903

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

None of the existing headforms can be considered a complete mechanical analog to the human head in terms of mechanical response. This paper describes the initial phases of the development of such a headform.

The first step in the development of the model was the determination of the pertinent mechanical properties of the tissues of the human head (scalp, skull bone, dura mater, and brain). A testing program which determined these properties at both static and dynamic strain rates is described and the results are summarized.

3/2 Anthropomorphic Data (Cont'd)

HS-008 637 (Cont'd)

The second phase of the program was to find and develop synthetic materials which duplicated the mechanical properties of the human tissues. Many materials were investigated, and modifications* to existing materials were made. The synthetic materials were tested by the same methods used in the human tissue tests. Results comparing the synthetic materials with their human tissue counterparts are given. Specific types of head injury phenomena that the model will be required to simulate are given.

Search terms: Head forms /
Materials tests; Head /Mechanical
properties; Skull /Mechanical
properties; Brain /Mechanical properties;
Human tissue mechanical properties

AVAILABILITY: In HS-008 628

4/0 OTHER SAFETY— RELATED AREAS

4/5 Information Technology

HS-008 638 Fld. 4/5
DIGITAL SIMULATION OF ENGINE
LUBRICATION SYSTEMS

by Robert S. Lo

Ford Motor Co., Dearborn, Mich.,
F18600

1971 17p 9 refs
Report no. SAE-710205

Presented at Automotive Engineering Congress, Detroit, Mich.,
11-15 Jan 1971.

This paper presents an analytical method of simulating an automotive engine lubrication system. It charts oil flow rates and distribution in a typical V-8 engine; this is followed with a detailed analysis of major components. Basic hydraulic diagrams and the lubrication circuit analysis are described with working equations. The computer

program with sample results is illustrated, and the calculations are compared with actual dynamometer test results. This analytical method can be used to determine the adequacy of oil pump capacity and to evaluate bearing design and oil path circuitry.

Search terms: Computerized simulation /Lubrication systems;
Digital computers /Computerized simulation; Hydraulic equipment /
Computerized simulation; Oil lines /
Computerized simulation; V 8 engines /Lubrication systems;
Dynamometers /Lubrication systems;
Computer programs /
Computerized simulation

AVAILABILITY: SAE

HS-008 639 Fld. 4/5

COMPUTER PROGRAM FOR
ENGINE COOLING RADIATOR
SELECTION

by Charles N. Kurland

General Motors Corp., Detroit, Mich.,
G06600

1971 7p
Report no. SAE-710209

Presented at Automotive Engineering Congress, Detroit, Mich.,
11-15 Jan 1971.

A computer program for selecting a radiator to provide a desired level of engine cooling, and for predicting the engine cooling performance with this radiator, has been formulated. The program is based upon the relationship of laboratory heat rejections to the in-car heat rejection of a baseline engine. Described are the methods of obtaining the engine heat rejection and the application of this information to the computer program. Comments concerning the benefits as well as the limitations of using this technique are included.

Search terms: Computer programs /Radiators; Heat rejection /Laboratory tests; Cooling systems /Radiators; Automobile engines /Cooling systems

AVAILABILITY: SAE

HS-008 640 Fld. 4/5; 5/4

SOLUTION OF AUTOMOTIVE
STRUCTURAL PROBLEMS USING
THE FINITE ELEMENT METHOD
AND COMPUTER GRAPHICS

by J. J. Hessel; S. J. Lammers

Ford Motor Co., Dearborn, Mich.,
F18600

1971 11p
Report no. SAE-710243

Presented at Automotive Engineering Congress, Detroit, Mich.,
11-15 Jan 1971.

One of the many computer oriented structural programs which utilizes the finite element technique is briefly discussed. Examples are presented to demonstrate the application of this program to actual product engineering structural problems. Correlation between predicted deflections and stresses and those obtained in the laboratory are presented.

Computer graphics provide a unique method of visually interrogating input data and displaying output data. Graphs, stress contours, and deflected structures obtained by this method are presented.

Search terms: Computerized design /Automobile design;
Deflection /Computerized design;
Stress measurement /Computerized design; Finite element method /
Automobile design

AVAILABILITY: SAE

4/8 Transportation Systems

HS-008 641 Fld. 4/8

THE PRESSURE FOR TRANSPORTATION BALANCE

by Victor W. Wigotsky

1970 12p
Report no. SAE-700187

Presented at Automotive Engineering Congress, Detroit, Mich., 12-16 Jan 1970.

Unified planning across different transportation modes is essential to alleviate a mounting deterioration in urban mobility. Bimodal vehicles, air

motors, tube vehicles, STOL, VTOL, and V/STOL are all part of the transportation "mix" being evaluated. The impact of electronics will be increasingly apparent in both personal and mass transit. These elements are discussed within a framework of today's realities and tomorrow's requirements.

Search terms: Transportation planning; Travel modes/Modal choice; Transportation problems/Urban areas; Urban transportation/Modal choice; Air cushion vehicles; Linear induction motors; Tube transportation; Short takeoff aircraft; Vertical takeoff aircraft; Public transportation; Transportation system capacities; Dual mode vehicles

AVAILABILITY: SAE

5/0 VEHICLE SAFETY

5/1 Brake Systems

HS-008 642 Fld. 5/1

THE CHRYSLER "SURE-BRAKE": THE FIRST PRODUCTION FOUR-WHEEL ANTI-SKID SYSTEM

by T. C. Schafer; J. W. Douglas

Bendix Corp., South Bend, Ind., B08400; Chrysler Corp., Detroit, Mich., C42600

1971 11p

Report no. SAE-710248

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

The paper outlines testing, development and operation of the first production four-wheel slip control system for passenger cars in the United States. The Chrysler Corporation calls the system "SURE-BRAKE", but it is more generally known as "anti-skid." Considerations that led Chrysler into the "SURE-BRAKE" system, the philosophy behind the system and a detailed explanation of its operation are given, as well as the development and testing leading to the release as an option on the 1971 Imperial.

dimension to brake engineering. Before the advent of wheel slip control systems, brake tests were always terminated at the point of skid, and were conducted mainly on black top or concrete roads. For the first time, thousands of stops were made at maximum deceleration on every available surface. The paper lists the results obtained and attempts to pass on some of the lessons learned in handling skidding vehicles.

Search terms: Brake systems/Antiskid devices; Chrysler Corp./Sure Brake; Vehicle control/Antiskid devices; Vehicle stability/Antiskid devices; Speed sensors/Antiskid devices; Logic circuits/Antiskid devices; Pressure modulator/Antiskid devices; Stopping distance/Antiskid devices; Road surfaces/Stopping distance; Road grades/Antiskid devices; Temperature endurance tests/Antiskid devices; Electromagnetic interference/Antiskid devices; Wheel slip control/Antiskid devices; Four wheel brakes/Antiskid devices

AVAILABILITY: SAE

HS-008 643 Fld. 5/1

INFLUENCE OF ROTOR METALLURGY ON THE WEAR OF FRICTION MATERIALS IN AUTOMOTIVE BRAKES

by S. K. Rhee

Bendix Corp., Southfield, Mich., B09000

1971 9p 7 refs

Report no. SAE-710247

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

A drag dynamometer was used to investigate the influence of rotor properties on the wear of automotive brake linings. The effects on lining wear of temperature, surface roughness, thermal conductivity, microstructure and composition were studied quantitatively, and the mechanisms governing lining wear were elucidated. Lining wear at high temperatures increases exponentially with increasing temperature, and decreases exponentially with

rotor. The wear increases parabolically with increasing surface roughness of the rotor. Also, coupling of a lining with a rotor having compatible composition and microstructure is very important for controlling the lining wear.

Search terms: Brake lining tests/Wear; Dynamometers/Wear tests; Brake lining wear/Friction; Brake lining wear/Laboratory tests; Brake drums/Thermal conductivity; Brake drum materials/Brake lining wear; Brake drums/Surface roughness; Brake lining wear/High temperature

AVAILABILITY: SAE

5/4 Design

HS-008 644 Fld. 5/4

CORROSION CONSIDERATIONS IN THE SELECTION OF MATERIALS IN AUTOMOTIVE TERMINAL SYSTEMS

by S. H. Butt; J. M. Popplewell

Olin Mathieson Chemical Corp., East Alton, Ill., O12300

1970 10p

Report no. SAE-700031

Presented at Automotive Engineering Congress, Detroit, Mich., 12-16 Jan 1970.

The corrosion performance of alloys considered suitable for automotive terminal systems are examined. General corrosion is insignificant when copper alloys are used. The designer can avoid stress corrosion by choosing from a complete range of mechanical and electrical property combinations in less sensitive and even immune copper alloys. Crevice corrosion can be minimized chiefly by designing to eliminate crevices and also by choice of less susceptible alloys. Finally, dezincification can be overcome by using less susceptible modified brasses or inhibited brasses; lower zinc alloys or alloys not containing zinc may also be used.

Search terms: Electric systems/Corrosion prevention; Copper alloys/Corrosion resistance;

5/4 Design (Cont'd)

HS-008 644 (Cont'd)

Brasses /Dezincification; Stress corrosion prevention /Copper alloys; Concentration cell corrosion prevention /Electric system design

AVAILABILITY: SAE

HS-008 645 Fld. 5/4

THE APPLICATION OF CHARGING SYSTEMS TO FARM, CONSTRUCTION, AND INDUSTRIAL MACHINERY

by R. A. Martin; G. R. Renner; G. A. Rows; G. H. Stenklyft

General Motors Corp., Anderson, Ind., G05400

1970 16p 7 refs
Report no. SAE-700686

Presented at Combined National Farm, Construction, and Industrial Machinery and Powerplant meetings, Milwaukee, Wisc., 14-17 Sept 1970.

New developments in charging systems offer improvements in performance, life, and reliability when the systems are properly applied to the vehicle. These developments include the Integral Charging System with a built-in integrated-circuit regulator, sealed side terminal battery, and improved application aids. An important objective of these developments is improved battery operation described in terms of the "Happy Battery" concept.

Search terms: Battery chargers; Battery charging /Farm vehicles; Battery charging /Construction equipment; Battery charging /Industrial trucks

AVAILABILITY: SAE

HS-008 646 Fld. 5/4

THE EFFECTS OF SHOT SIZE ON THE RESIDUAL STRESSES RESULTING FROM SHOT PEENING

by G. T. Robertson

Chrysler Corp., Detroit, Mich., C42600

1968 6p
Report no. SAE-710284

Presented at X-Ray Fatigue Division, SAE Fatigue Design and Evaluation Committee, Ann Arbor, Mich., 24-25 Sept 1968.

In the shot peening of automotive parts, it is desirable to obtain the best possible stress distribution for a particular application without creating an undesirable surface condition which would be harmful to the life of the part. This report describes the influence of shot size upon residual stress curves. It was found that these curves could be represented by a Gaussian type function which clearly illustrated the effect of changing shot size. Results showed that the maximum compression is located increasingly further subsurface and the total in depth influence of the shot peening becomes greater as the shot size is increased.

Search terms: Shot peening; Stress (mechanics) /Statistical analysis; Service life /Stress (mechanics); Fatigue (materials) /Service life

AVAILABILITY: SAE

5/6 Fuel Systems

HS-008 647 Fld. 5/6

AN OZONE-NO CHEMILUMINESCENCE METHOD FOR NO ANALYSIS IN PISTON AND TURBINE ENGINES

by H. Niki; A. Warnick; R. R. Lord

Ford Motor Co., Dearborn, Mich., F18600

1971 7p
Report no. SAE-710072

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

A method for the measurement of nitric oxide (NO) in photochemical smog research was developed using the chemiluminescence from the rapid reaction between ozone and NO. An instrument based on this method has been constructed; it is applicable to a number of automotive problems. This

NO detector has been tested extensively in both laboratory and dynamometer experiments, and has been shown to have several outstanding features: detection sensitivity of 0.01-5000 ppm, selective detection for NO, continuous monitoring with fast response time, and good stability and ease of operation.

Examples of results obtained in turbine experiments and in vehicle exhaust analysis are presented.

Search terms: Nitrogen oxides /Smog; Measuring instruments /Smog; Dynamometers /Exhaust emissions measurement; Chemiluminescence; Ozone /Chemical reactions; Nitrogen oxides /Chemical reactions; Turbine engines /Exhaust emissions measurement; Automobile engines /Exhaust emissions measurement; Measuring instruments /Exhaust emissions measurement

AVAILABILITY: SAE

HS-008 648 Fld. 5/6

AUTOMOTIVE EMISSIONS RESEARCH AND THE COORDINATING RESEARCH COUNCIL PROGRAM

by C. E. Moser

Texaco, Inc., New York, T13200

1971 5p
Report no. SAE-710075

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

The Coordinating Research Council research program on vehicle emissions consists of some thirty projects with a three-year projected cost of more than \$10 million. The Functional Air Pollution Research Advisory Committee and the project manager oversee these studies, encompassing the fields of engineering, atmospheric chemistry, and medicine. Results are being utilized by industry and government to reduce the level of emissions now contaminating the atmosphere.

Search terms: Emissions; Exhaust emissions /Engineering; Air pollution control; Smog; Health hazards research; Government industry cooperation; Coordinating Research

Council, Inc.; Exhaust emissions / Chemistry; Exhaust emissions / Medicine

AVAILABILITY: SAE

HS-008 649 Fld. 5/6

ANALYSIS AND EXPERIMENTS ON CARBURETOR METERING AT THE TRANSITION REGION TO THE MAIN SYSTEM

by Kazuo Shinoda; Hiroshi Koide; Akira Yui

Toyota Motor Co. Ltd. (Japan), T30000

1971 16p 5 refs

Report no. SAE-710206

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

A series of analyses and experiments has been carried out on the problem of poor air/fuel ratio characteristics at the transition region from the idle system to the main system. The fuel supply characteristic of the idle system, as well as that of the main system, has been treated as a function of intake air-flow rate.

It has been shown theoretically that the behavior of the fuel in the transition region results from the fuel passage construction of the conventional type of carburetor, and that a uniform air/fuel ratio can never be supplied in the transition region without a main air-bleed system. The effects of the main air-bleed system on fuel supply characteristics at the transition region have been investigated quantitatively. The mechanism of fuel supply at the transition region has been confirmed through experiments made on actual parts.

Search terms: Air fuel ratio / Carburetors; Air fuel ratio / Mathematical models; Fuel systems / Air fuel ratio; Air flow / Fuel systems; Idling / Fuel systems

AVAILABILITY: SAE

HS-008 650 Fld. 5/6

THE EFFECT OF EXHAUST SYSTEM GEOMETRY ON EXHAUST DILUTION AND ODOR INTENSITY

by J. M. Colucci; G. J. Barnes

General Motors Corp., Detroit, Mich., G06600

1971 12p

Report no. SAE-710219

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

Diesel exhaust gas dilution and odor intensity were measured in the immediate vicinity of a transit bus equipped with a rear-mounted horizontal exhaust pipe, a rear-mounted vertical exhaust pipe, and a roof-top diffusion system.

Exhaust dilution ratios were measured indoors during vehicle idle operation, using propane added to the exhaust gas as a tracer. Exhaust odor intensities were measured also indoors during vehicle idle operation by a human panel, using a threshold odor measurement technique.

On the average, the dilution of the exhaust gas around the bus with the vertical exhaust pipe was about eight times greater than it was with the horizontal pipe. Odor intensity, as measured by the threshold response distance, was about 35% less with the vertical pipe than with the horizontal pipe. The roof-top diffuser was not as effective as the vertical exhaust pipe in increasing exhaust gas dilution or in reducing exhaust odor intensity.

These results indicate that the exhaust system geometry may have a considerable effect on exhaust odor intensity of diesel-powered vehicles.

Search terms: Diesel engine exhaust emissions / Buses; Human panels / Exhaust odors; Exhaust systems / Diesel engines; Exhaust odors / Buses; Propane; Exhaust emission control device tests; Vertical exhaust systems; Exhaust pipe location

AVAILABILITY: SAE

HS-008 651 Fld. 5/6

RESERVOIR DESIGN FOR MOBILE EQUIPMENT HYDRAULIC CIRCUITS

by Edward A. Wirtz

Caterpillar Tractor Co., Peoria, Ill., C33000

1970 7p

Report no. SAE-700722

Presented at Combined National Farm, Construction and Industrial Machinery and Powerplant Meetings, Milwaukee, Wisc., 14-17 Sept 1970.

Hydraulic reservoir design has, seemingly, low priority when a new vehicle is being designed; but if a design engineer is careless about his reservoir design the entire vehicle performance can be jeopardized seriously. When he thinks of a loader he should not think of a prime mover with a bucket as an attachment. He should think of the hydraulic circuit and implement as the basic tool, being supported by the remainder of the vehicle. The seven basic items to be considered when designing reservoirs are: envelope size, shape, location on vehicle, components in the tank, mounting, serviceability, and cost.

Search terms: Air entrainment / Hydraulic design factors; Hydraulic fluids / Tanks (containers); Hydraulic equipment / Tanks (containers)

AVAILABILITY: SAE

HS-008 652 Fld. 5/6

VEHICLE AIR POLLUTION--THE PROBLEM AND ITS SOLUTION

by William P. Lear; Kenneth L. Nall

Lear Motor Corp., Reno, Nev., L03300

1970 29p 82 refs

Report no. SAE-710272

Presented at SAE Chicago Section meeting, 12 May 1970.

Air pollution control is one of the most urgent problems of today. Aspects of the problem discussed include: primary sources of air pollution; urban air pollution; pollutant concentration; health hazards due to air pollutants; the reduction of air pollution from motor vehicles; emission control devices; costs of pollution control. Solutions for the air pollution problem include: steam powered automobiles; hybrid turbine-electric automobiles; substitution of public transportation for private vehicles. A mathematical basis for computation of future air pollution due to motor vehicles is included.

Search terms: Air pollution control; Air pollutants / Urban areas; Air

5/6 Fuel Systems (Cont'd)

HS-008 652 (Cont'd)

pollution emission factors; Air pollution control costs; Steam automobiles; Hybrid vehicles; Electric automobiles; Gas turbine automobiles; Mathematical analysis /Air pollution emission factors; Forecasting /Air pollution emission factors; Air pollutants /Health hazards; Vehicle air pollution /Forecasting; Vehicle air pollution /Mathematical analysis; Public transportation; Lear steam automobiles

AVAILABILITY: SAE

5/7 Glazing Materials

HS-008 653 Fld. 5/7

TEMPERED VERSUS HPR LAMINATED WINDSHIELDS: A COMPARATIVE STUDY OF UNITED KINGDOM AND UNITED STATES COLLISIONS

by G. M. Mackay; A. W. Siegel; P. V. Hight

Birmingham Univ., Warwick (England), B16200; California Univ., Los Angeles, Vehicular Trauma Research Group, C21900

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p369-87

19 refs

Report no. SAE-700911

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Data are presented from two field studies on the collision injuries which result from contact with tempered glass and 0.030 in. (0.76 mm) high penetration resistant (HPR) laminated glass windshields. Two sets of similar automobile collisions are analyzed. The first set consists of European and Japanese cars imported into the United States (in Southern California). The second set is drawn from a study of British cars involved in collisions in England, all of which had tempered windshields.

The data presented indicate that tempered windshields give rise to a higher incidence of injury and more severe injuries than the 0.030 in. HPR laminated windshields under similar impact conditions. These differences are statistically significant. The importance of severe injuries from the edges of shattered tempered windshields is discussed, together with injuries which result from the passing of occupants through the plane of the windshield to strike the car hood or cowl.

Eye injuries from the two types of windshields are discussed, together with the effect on the injury mechanisms when the windshield becomes detached during the collision.

Search terms: Tempered glass caused injuries; Laminated glass caused injuries; European vehicles /Glazing materials; Japanese vehicles /Glazing materials; British vehicles /Glazing materials; Eye injuries /Windshields; Collisions /Windshield caused injuries

AVAILABILITY: In HS-008 628

5/14 Occupant Protection

HS-008 654 Fld. 5/14

BABOON TOLERANCE TO LINEAR DECELERATION (-G_x): LAP BELT RESTRAINT

by Thomas D. Clarke; James F. Sproufske; Edwin M. Trout; Harold S. Klopfenstein; William H. Muzzy; C. D. Gragg; Charles D. Bendixen

Aeromedical Research Lab. (6571st), Holloman AFB, N. Mex., A08400

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p279-98

25 refs

Report no. SAE-700906

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

The tolerance to abrupt linear deceleration (-G_x) and the subject response to a lap belt restraint system were investigated. Nineteen adult male baboons comprised the test pool. The effects of impacts of 8.6-40 g were

studied, with nonsurvivability used as the index of tolerance.

The results indicated that the tolerance to impact (LD₅₀) approximated a 32 g sled deceleration. Lethality was presumed attributable to the secondary impact as the head contacted the floor of the sled. Predominant lethal injuries included avulsion of the atlanto-occipital articulation and dislocation fractures of the cervical vertebrae with resulting transection of the spinal cord.

Excellent linear correlations were established between peak lap belt and seat pan forces versus maximum sled deceleration. Likewise, a linear relationship was found between peak head angular accelerations and maximum sled deceleration.

Search terms: Deceleration tolerances /Baboons; Seat belts /Force; Impact tests /Fatalities; Gravitation /Force

AVAILABILITY: In HS-008 628

HS-008 655 Fld. 5/14

BABOON TOLERANCE TO LINEAR DECELERATION (-G_x); AIR BAG RESTRAINT

by Thomas D. Clarke; James F. Sproufske; Edwin M. Trout; C. D. Gragg; William H. Muzzy; Harold S. Klopfenstein

Aeromedical Research Lab. (6571st), Holloman AFB, N. Mex., A08400

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p263-78

15 refs

Report no. SAE-700905

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

The tolerance to abrupt linear deceleration (-G_x) and the subject interaction with an air bag plus lap belt and air bag only restraint systems were investigated. Twenty adult male baboons comprised the test pool. Peak sled decelerations ranged 8.6-123 g. The results indicated that the tolerance to impact (LD₅₀) utilizing an air bag with or without lap belt was in excess of 120 g. The severest injuries were attributable to the lap belt, and

included rupture of the rectus abdominus and quadriceps femoris muscles plus diaphragmatic tearing. There were no significant injuries to subjects restrained with only an air bag.

Excellent linear correlations were established between peak lap belt forces and maximum sled deceleration. Comparative evaluation of the air bag restraint with a previously reported lap belt study was made when applicable.

Search terms: Deceleration tolerances /Baboons; Air bag restraint systems /Force; Seat belts /Force; Gravitation /Force

AVAILABILITY: In HS-008 628

HS-008 656 Fld. 5/14

EVALUATION OF THE LAP BELT, AIR BAG, AND AIR FORCE RESTRAINT SYSTEMS DURING IMPACT WITH LIVING HUMAN SLED SUBJECTS

by C. D. Gragg; C. D. Bendixen; T. D. Clarke; H. S. Klopfenstein; J. F. Sprouffske

Aeromedical Research Lab. (6571st), Holloman AFB, N. Mex., A08400

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p241-62

11 refs

Report no. SAE-700904

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

Abrupt linear decelerations ($-G_x$) were conducted with human volunteers in order to study the loading to the human anatomy while restrained with the lap belt, lap belt plus air bag, and Air Force harness systems.

Impulses and peak forces in the lap belts and peak forces in the seat pan, seat back, and foot cells were measured and compared. Each subject was compared with himself using the different systems, and the range and mean of these comparisons are shown. The results indicated that in comparison with the lap belt only system, both the lap belt plus air bag and the Air Force harness systems significantly reduced the impulses and peak forces transmitted to the pelvis.

Search terms: Human body impact tolerances; Human deceleration tolerances; Air bag restraint systems; Seat belts; Shoulder harnesses; Pelvis /Impact forces

AVAILABILITY: In HS-008 628

HS-008 657 Fld. 5/14

LAP-SHOULDER RESTRAINT EFFECTIVENESS IN THE UNITED STATES

by W. D. Nelson

General Motors Proving Ground, Milford, Mich. Safety Research and Development Lab., G10200

1971 9p

Report no. SAE-710077

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

Lap-shoulder belts, although infrequently used by vehicle occupants, are demonstrating a remarkably high reduction of injury in collisions where they were used. Of the 160 cases found in the GM files where at least one occupant was wearing the lap-shoulder belt combination restraint, 60% of the vehicles had heavy damage of the type often associated with occupant injury; however, 99% of the lap-shoulder belt users either had no injury or only minor injury. The only two fatalities found in the study involved accidents occurring under unusual circumstances.

This paper describes 18 of the most severe damage and/or injury cases by means of photographs and collision descriptions. Some grouping of body injuries is also listed. These data illustrate that the use of different occupant restraint configurations (unrestrained, lap belt, and lap-shoulder belt) affect the frequency and severity of injuries to various body areas.

Search terms: Three point restraint systems /Fatalities; Injury prediction from vehicle damage; Three point restraint system /Injury prevention; Injuries by body area /Statistics; Accident case reports /Restraint system usage

AVAILABILITY: SAE

HS-008 658 Fld. 5/14

AN ENERGY-ABSORBING RESTRAINT SYSTEM

by R. W. McLay; F. J. Blackstone; P. K. Das

Vermont Univ., Burlington, V04200; Yale Univ., New Haven, Conn., Y00300

1971 15p 47 refs

Report no. SAE-710078

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

An energy-absorbing restraint system that limits the accelerations of a passenger in a forward auto crash to 20 g's is presented. The device absorbs energy through the continuous bending of a steel wire. Results of an elastic-plastic analysis of the device indicate that it closely approximates a constant force energy absorber; the force is only a weak function of velocity. Preliminary results from drop tests and high-speed impact tests to 100 mph indicate that the absorber can limit acceleration to a specified value. The results of two tests in which the device was used to restrain a volunteer during a head-on crash the volunteer. In each crash a vehicle driven at 50 mph impacted a parked vehicle. The results show that the restraint system protects a man in a forward crash by limiting his accelerations to a level below the threshold of injury for the vital organs.

Search terms: Energy absorbing systems /Steel wire; Restraint system assemblies /Steel wire; Drop tests /Energy absorbing systems; Steel wire /Bending; Steel wire /Deformation; Speed tests /Energy absorbing systems; Road tests /Energy absorbing systems; Laboratory tests /Energy absorbing systems; Impact tests /Energy absorbing systems; Energy absorbing systems /Equations; Gravitation /Energy absorption

AVAILABILITY: SAE

HS-008 659 Fld. 5/14

VOLUNTEER, ANTHROPOMETRIC DUMMY, AND CADAVER RESPONSES WITH THREE AND FOUR POINT RESTRAINTS

5/14 Occupant Protection (Cont'd)

HS-008 659 (Cont'd)

by L. M. Patrick; K. R. Trosien

Wayne State Univ., Detroit, Mich., W09600

1971 26p 30 refs

Report no. SAE-710079

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

The paper gives an evaluation of the performance of lap and shoulder belt restraint systems currently being used in American-built automobiles. Comparisons are made of the response characteristics of a volunteer, an anthropometric dummy, and a cadaver when subjected to identical collision environments while wearing a three or four point torso restraint system as occupants of the right front seat. Simulated frontal force barrier collisions in a modified automobile provided the realistic environment for the restraint system performance study. Human tolerances, interior vehicle geometry, and the interaction of the restrained occupant with the vehicle during the collision are reported in detail.

Search terms: Three point restraint systems/Restraint system effectiveness; Four Point restraint systems/Restraint system effectiveness; Cadavers/Impact tests; Anthropometric dummies/Impact tests; Test volunteers/Impact tests; Restraint system effectiveness/Impact tests; Impact tolerances; Oscillograph records/Impact tests; Three point restraint systems/Impact tests; Four point restraint systems/Impact tests; Submarining/Restraint system effectiveness; Speed studies/Restraint system effectiveness; Neck motion range/Impact tests

AVAILABILITY: SAE

HS-008 660 Fld. 5/14; 1/3

THE NATURE OF SEAT BELT INJURIES

by James S. Williams

Rochester Univ., N. Y. School of Medicine, R17400

Published in *Proceedings of Fourteenth Stapp Car Crash Conference*, 1970, p44-65

63 refs

Report no. SAE-700896

Presented at the Fourteenth Stapp Car Crash Conference, Ann Arbor, Mich., 17-18 Nov 1970.

A study was made of the histories of accidents in which the victims were injured by safety belts. The three types of safety belts—lap, two point, and three point—each produced a characteristic injury pattern. Without restraining systems, more of the accidents would have resulted in fatalities, but the safety belt injuries were often extremely severe. Statistics are given of the number and type of injury for each form of safety belt, and the conclusion is drawn that a combination of shoulder and lap belt is the most effective in preventing injury and mortality.

Search terms: Safety belts/Injury causes; Seat belt use/Fatalities; Safety belts/Medical case reports; Seat belts/Fractures; Three point restraint systems/Fractures; Three point restraint systems/Abdominal injuries; Seat belts/Abdominal injuries; Seat belts/Spinal injuries; Seat belts/Pelvic injuries; Shoulder harnesses/Fractures; Shoulder harnesses/Abdominal injuries

AVAILABILITY: In HS-008 628

HS-008 661 Fld. 5/14; 5/7

AUTOMOBILE OCCUPANT EJECTION THROUGH THE SIDE DOOR GLASS

by D. F. Huelke; Harold W. Sherman
Michigan Univ., Ann Arbor, Medical School, M42000; Michigan Univ., Ann Arbor, Highway Safety Research Inst., M40800

1971 11p 20 refs

Report no. SAE-710076

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

Ejection of car occupants through door openings has been markedly

reduced in the new model cars. However, cases have now been found where car occupants are being ejected through the side door glass opening or directly through the side glass. Twenty-one cases of ejection through the side glass are described.

Search terms: Ejection through side windows/Statistics; Vehicle age/Ejection through side windows; Accident case reports/Ejection through side windows; Restraint system usage/Ejection through side windows

AVAILABILITY: SAE

5/15 Propulsion Systems

HS-008 662 Fld. 5/15; 5/6

GENERAL MOTORS' STEAM POWERED PASSENGER CARS—EMISSIONS, FUEL ECONOMY AND PERFORMANCE

by P. T. Vickers; J. R. Mondt; W. H. Haverdink; W. R. Wade

General Motors Research Labs., Warren, Mich., G10800

1970 24p 40 refs

Report no. SAE-700670

Presented at SAE National West Coast meeting, Los Angeles, Calif., 24-27 Aug 1970.

Two steam powered passenger cars have been designed, built, and tested. The *SE-101* is an intermediate sport coupe incorporating the comfort and convenience features of a modern passenger car and vehicle performance comparable to a low powered automobile. The *SE-124* is a very low power intermediate sedan with manual start and semi-automatic control. The characteristics of these cars were evaluated relative to the operational requirements of current transportation needs, with particular emphasis on exhaust emissions. Start-up time, exhaust emissions, fuel economy, acceleration, and water consumption data are presented. Although any one of these characteristics may be improved at the expense of others, it does not appear that any compromise can satisfy all of the areas required by today's motorist.

Search terms: Steam automobile performance; Steam automobiles / Fuel economy; Steam automobiles / Exhaust emissions; Steam automobiles / Acceleration; Steam automobiles / Water consumption

AVAILABILITY: SAE

5/17 Safety Defect Control

HS-008 663 Fld. 5/17; 5/11

OVERVIEW OF TRANSDUCERS AND SENSORS FOR DIAGNOSTICS

by Henry G. Tobin

IIT Research Inst., Chicago, Ill., 106000

1970 11p 9 refs
Report no. SAE-700495

Presented at SAE Mid-year meeting, Detroit, Mich., 18-22 May 1970.

The wide interest in the development of diagnostic techniques for automotive purposes has led to developments in several areas. These include sensing methods, signal processing methods, and studies of how mechanical systems fail. This paper, concerned with only the first of these categories, presents an overview of sensors with emphasis on new developments that may be useful in the diagnostic field. Among the parameters which may be measured in automotive diagnostic systems are pressures, speeds, flow rates, temperatures, vibration, and electrical measurements. This paper will discuss various methods by which such parameters can be measured.

Search terms: Sensors / Diagnosis; Transducers / Diagnosis; Measuring instruments / Pressure; Measuring instruments / Speed; Measuring instruments / Flow; Measuring instruments / Temperature; Measuring instruments / Vibration; Measuring instruments / Electricity; Failures / Measuring instruments

AVAILABILITY: SAE

5/18 Steering Control System

HS-008 664 Fld. 5/18

EVALUATION OF THE LATERAL STABILITY OF AN AUTOMOBILE

WITH NONLINEAR COMPONENT TO INCREASING MAGNITUDE GUST AND TIRE LOAD

by J. Mahig

Florida Univ., Gainesville, FL6200
1971 11p 16 refs
Report no. SAE-710287

Presented at Automotive Engineering Congress, Detroit, Mich., 11-15 Jan 1971.

Knowledge of that component of a vehicle's handling characteristics represented by the vehicle dynamics is necessary to analyze the driver's role in controlling the vehicle. One aspect of this problem is determination of the effect on the stability under differing road conditions in the linear as well as non-linear region. The simulation presented evaluates the response of the vehicle suspension system to suddenly applied external impulses which are identified as caused by wind gust and road disturbance. This analysis considers only the effect on the lateral stability of the vehicle. Thus this representation is assumed completely decoupled from the longitudinal dynamics of the vehicle. Proceeding in this fashion makes it possible to study the effect of large wind gust and lateral road impacts on the lateral stability of a vehicle containing non-linear tire characteristics. The effects in the nonlinear region are clearly demonstrated with the aid of a conventional root locus plot.

Search terms: Vehicle dynamics; Vehicle handling; Vehicle stability / Wind forces; Lateral force / Vehicle stability; Tire characteristics / Vehicle stability; Equations of motion / Vehicle stability; Mathematical analysis / Vehicle stability; Tire loads / Vehicle stability; Suspension systems / Evaluation

AVAILABILITY: SAE

5/20 Trucks and Trailers

HS-008 665 Fld. 5/20

ACCELERATION PERFORMANCE OF HIGHWAY DIESEL TRUCKS

by Thomas D. Hutton

Freightliner Corp., Portland, Oreg., F27000

1970 13p
Report no. SAE-700664

Presented at SAE National West Coast meeting, Los Angeles, Calif., 24-27 Aug 1970.

Level road acceleration performance measurements of randomly selected intercity diesel trucks are presented. The ratio of gross combination vehicle weight to gross engine horsepower is correlated with acceleration performance. Test results are presented in graph form displaying distance vs. time, speed vs. time, and distance vs. speed for weight to power ratios of 100, 200, 300, and 400 pounds per horsepower. The effect of high torque rise engines with 5-speed transmissions as well as transmission shift time on acceleration performance is also reported. A graphical determination of passing time and distance for a low speed pass maneuver is also presented, based on actual acceleration performance data.

Search terms: Acceleration response / Trucks; Vehicle weight / Horsepower; Weight to power ratio / Trucks; Torque / Diesel engines; Transmissions / Trucks; Passing / Acceleration; Time factors / Passing; Speed / Passing; Mathematical models / Passing

AVAILABILITY: SAE

HS-008 666 Fld. 5/20

A RATIONAL APPROACH TO THE REGULATION OF TRUCK PERFORMANCE

by L. F. Donnelly

MacK Trucks, Inc., Allentown, Pa., M00400

1970 6p
Report no. SAE-700663

Presented at SAE National West Coast meeting, Los Angeles, Calif., 24-27 Aug 1970.

The premise of this paper is that the commonly heard proposals for regulating maximum gross loads of heavy commercial vehicles either do not reflect actual performance potential or

5/20 Trucks and Trailers

(Cont'd)

HS-008 666 (Cont'd)

are not practical to apply. A refinement of the gross weight per unit horsepower method is proposed in which the average horsepower available over the operating range of the engine would be substituted for any instantaneous value of power. This modification offers the advantage of reflecting the benefit of increases in the number of gear reduction steps and tends to compensate for differences in horsepower versus engine speed characteristics.

Search terms: Commercial vehicles /Vehicle weight limits; Trucks /Vehicle weight limits; Vehicle weight limits /Horsepower; Engine speeds /Horsepower; Performance characteristics /Trucks; Gear speeds /Trucks

AVAILABILITY: SAE

5/22 Wheel Systems

HS-008 667 Flid. 5/22

HYDRAULIC MOTORIZED WHEEL APPLICATIONS

by Ralph W. Holmes

Kelsey-Hayes Co., Romulus, Mich., K03600

1969 8p

Report no. SAE-690555

Presented at SAE National West Coast meeting, Seattle, Wash., 11-14 Aug 1969.

This paper describes the application of hydraulically powered wheels to a logging trailer which is pulled by a 225-HP tractor. It discusses the advantages of the hydrostatic transmission as a means of powering the trailer. The hydraulic circuitry and its operation is examined. A cutaway view of the wheel is used to explain the operating features. Performance figures are displayed and component arrangement on the tractor are shown. Other applications of the same hydraulic wheel are presented.

Search terms: Hydraulic equipment /Wheels; Tractor trailers /Wheels; Hydrostatic transmissions /Tractor trailers

AVAILABILITY: SAE

NHTSA DOCUMENTS

NHTSA Contractors Reports

HS-800 322 Flid. 3/6; 4/1

IMPROVING THE ENFORCEMENT OF DRIVER LICENSE DENIALS, SUSPENSIONS, AND REVOCATIONS. PT. 1, PRELIMINARY GUIDELINES. FINAL REPORT

Exotech Systems, Inc., Washington, D.C., E23800

Oct 1970 43p

Contract FH-11-7283

Report no. PB-195 811

A systems approach was taken toward the mechanism of imposing and enforcing denials, and advanced technology was investigated to identify the most promising ways to improve denial enforcement. Actions which can improve the enforcement of denials are: application of management principles; commitment to objectives and the enforcement of mandatory statutes; public accountability; reducing ease of denial violation; improving incentives to comply with denials; creation of special files for denied operators accessible through the criminal information system by registration or license data; driver surveillance using data transmission technology. A checklist to assist agencies in the formulation of work plans for denial management and enforcement and evaluating progress is included.

Search terms: Driver license denial /Traffic law enforcement; Driver license suspension /Traffic law enforcement; Driver license revocation /Traffic law enforcement; Systems analysis /Traffic law enforcement; Traffic law enforcement /Planning; Traffic law enforcement /Management; Traffic law enforcement /Evaluation; Traffic law enforcement /Statistics; Traffic laws /Compliance; Traffic

records /Driver license denial; Traffic records /Driver license suspension; Traffic records /Driver license revocation

AVAILABILITY: NTIS

HS-800 323

IMPROVING THE ENFORCEMENT OF DRIVER LICENSE DENIALS, SUSPENSIONS, AND REVOCATIONS. PT. 2, TECHNICAL REPORT. FINAL REPORT

Exotech Systems, Inc., Washington, D.C., E23800

Oct 1970 122p 163 refs

Contract FH-11-7283

Report no. PB-195 812

The objective of this study was to identify and propose effective methods for improved enforcement of denials and identify needed programs of research to develop improved enforcement techniques. Methods to administer and enforce license denials and the problems associated with various measures were studied through research, literature reviews, and interviews. The institutions and policies for the administration and enforcement of license denials, as well as the national scale of the problem, have been considered using a systems approach: functions performed by agencies and their relationships have been examined as elements of a system; objectives and their resource implications are considered; and a broad comprehensive view of the problem is presented. Recommendations cover topics with varying expected contributions to increase compliance.

Search terms: Driver license denial /Traffic law enforcement; Driver license suspension /Traffic law enforcement; Driver license revocation /Traffic law enforcement; Systems analysis /Traffic law enforcement; Traffic laws /Compliance; Traffic records /Driver license denial; Traffic records /Driver license suspension; Traffic records /Driver license revocation; Traffic law enforcement /Management; State laws /Traffic law enforcement; Traffic law enforcement /Planning

AVAILABILITY: NTIS



executive summary

A SYNOPSIS OF A RECENTLY RELEASED NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION RESEARCH REPORT

DEALER WARRANTY: GARAGE REPAIR FOR TRUCKS AND BUSES

The objectives of the study were to assess the safety adequacy of general repair practices and policies for trucks and buses as accomplished by various repair and maintenance facilities nationally. Vehicle systems limited to: Brake; Steering; Suspension; Fuel; and Engine Controls and Accessories were to be considered with special emphasis being placed on categorization of results as:

- a. Scheduled maintenance and repair
- b. Unscheduled maintenance and repair.

Contract FH-11-7285
Operations Research, Inc.
1400 Spring Street
Silver Spring, Maryland 20910
DOT/HS-800 290
PB-194 975

Award Amount: \$47,236.00
Date Report Due: 7/31/70
Date Report Rec'd: 9/8/70
Release Date: 10/23/70

SCOPE

In order to maintain a viable study plan within the prescribed level of effort, certain limitations in scope were required. With respect to the set of safety related components, only the following were considered in scope:

Brake systems
Steering systems
Suspension systems
Fuel systems
Power plant controls and accessories

Emphasis was placed upon categorization of results by:

- Scheduled maintenance (PM) and repair (Category A)
 - Quality of Workmanship and Qualifications; Frequency of Defects/Repairs Detected During Scheduled Maintenance; Adequacy of Equipment, Facilities, and Personnel
- Unscheduled maintenance and repair (Category B)
 - The Frequency of Re-repair Required to Complete Repairs Performed Following Breakdown Enroute; The Quality of

Workmanship Involved in Repairs Performed as a Result of Unscheduled Breakdown Enroute; The Adequacy of Vehicle Component and Subsystem Coverage Provided by Existing Maintenance Schedules; Bureau of Motor Carrier Safety Statistics.

MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Findings and Conclusions

- Repairs performed on the systems of interest appeared to be of high quality and effectiveness, given that the need for repair was established. This conclusion is based largely upon the almost non-existent rate of re-repair reported, although there was some concern noted regarding the adequacy of out-of-house repair compared to inhouse repair.
- There was no indication that repair quality was degraded as a result of facility, equipment or manpower qualification restrictions or inadequacies.
- The quality and performance of replacement parts did not appear to pose any special problems and, from the responses, may be considered to be equal to that of the original equipment.

- No cases were reported or indicated for which safety malfunctions resulted from improper or substandard replacement parts and materials.
- Responding facilities reported that an average of 70 percent of all repairs to the systems of interest are initiated and performed to correct deficiencies detected during scheduled maintenance. An additional average of about 27 percent is initiated as a result of driver complaint (the remaining 3 percent being attributable to on-the-road breakdown).
- For the systems of interest, scheduled maintenance results in repair about once in four PM inspections, with minor adjustments not being considered repair. For operator reported deficiencies, subsequent checkout results in a repair action in about half the cases.
- The frequency of re-repair required to complete repairs performed following breakdown enroute was reported to be negligible, although respondents considered the general quality of out-of-house repair inferior to that performed inhouse. This apparent anomaly may reflect a lack of confidence due to lack of control over the repair process in these cases. For either heavy or passenger vehicles this strong concern for maximizing vehicle availability by control of the repair process will have a favorable effect on vehicle safety status.
- The vehicle component and subsystems coverage provided by existing maintenance schedules appears to be adequate.
- Reviews of accident statistics for heavy vehicles indicate that about 5 percent of the reviewed accidents were attributable to mechanical defects (with brakes and tires, in that order, the most prevalent). The out-of-service rates reported (around 20 percent by the Bureau of Motor Carrier Safety from roadside checks also, in all likelihood understate the actual out-of-service condition. To the extent that it is considered important to reduce these rates, this investigation indicates that the major contributor is lack of detection of the need for repair rather than inadequacy of the repair itself or the replacement parts used.

Recommendations

- Verification of these interim results is suggested through a more comprehensive survey

which might be implemented in conjunction with the Census Bureau's next Truck Inventory and Use Survey (by Igw, in 1972). This "piggyback" arrangement would be a cost-effective way to obtain more representative data. An experimental approach to verification of repair diagnosis and procedure is necessarily costly but remains the most potent means of obtaining a truly independent check.

- To the extent that additional research in this area is of sufficiently high priority in relation to other NHTSB programs, it is recommended that the following areas be more intensively investigated:
 - The relationship between the quality of inhouse versus out-of-house repair.
 - The extent to which there is rigorous adherence to claimed maintenance policies.
 - The economic aspects of maintenance (that appear to underlie the maintenance policies and practices through the strong motivation for maximizing on-the-road availability).
 - The development of a rudimentary model of the maintenance process of that field data collection programs can be viewed as means of estimating the relevant parameters and to allow, after calibration, for predictions and comparisons.
- In view of the statistics concerning accidents and out-of-service conditions, as well as the indication that lack of detection of the need for repair appears to be a more significant contributory factor than inadequate repair, it is recommended that the roadside checks performed by the Bureau of Motor Carrier Safety be continued and expanded as available resources permit.

The Contract Manager has certified that the contractor's work has been satisfactorily completed and that all contractual obligations have been met.

The opinions, findings, and conclusions expressed in this summary are those of the contractor and not necessarily those of NHTSA.

Availability; The report may be ordered in paper copy (PC) or microfiche (MF) from NTIS. Order DOT/HS-800 290 or PB-194 975.



executive summary

OPSIS OF A RECENTLY RELEASED NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION RESEARCH REPORT

IMPACT INTRUSION CHARACTERISTICS OF FUEL SYSTEMS

The purpose for the project was to investigate crash induced motor vehicle fuel system failures and to recommend the most effective barrier test procedures for evaluating fuel system integrity.

Contract FH-11-7309
Cornell Aeronautical Laboratory, Inc.
4455 Genesee Street
Buffalo, New York 14221
DOT/HIS-800 296
PB-195 347

Award Amount: \$24,306.00
Report Release Date: 10/27/70

Background

The National Highway Safety Bureau, in connection with its goal of improving the safety and crashworthiness of motor vehicles offered to the American public, has an interest in the integrity of fuel systems where such systems may be accident-damaged and caused to leak, thereby posing a serious fire hazard. Of immediate interest to the Bureau is the promulgation of safety standards and compliance procedures to test the adherence of vehicles to these standards.

The first step toward establishment of such standards and compliance test procedures should be the determination of the type of accidents which do, in fact, cause fuel system failure. The files of Automotive Crash Injury Research (ACIR) and Automobile Manufacturers and Association, Inc. (AMA) data collection programs produced information in this area. The general literature was another information source. Data from this source, while chiefly of a design nature, did tend to spotlight apparent problem areas, such as tank location, retention methods, filler pipe construction, and fuel line and electrical system wiring routing.

Few collision tests related to automotive fuel systems are described in the literature. They are often oriented more toward producing a failure and illustrating its consequence than to measuring the forces, deformations and accelerations necessary to cause failure or, conversely, characterizing those impacts which a fuel system can

aim was taken at the fuel tank, and the collision was of such magnitude as to guarantee gross fuel tank failure. (Reference 1 in the report).

In an effort to economically acquire more test data, active CAL projects involving crash testing were monitored. This enabled data to be obtained on a "piggy back" basis; that is, the primary purpose of each test was not fuel system impact intrusion but was connected with other investigations. The vehicle fuel tanks were 90% filled with dyed Stoddard Solvent (a mineral spirit used here to simulate gasoline) and leakage as well as accelerations were noted.

It is felt that no practical fuel system can be devised that could not, with sufficient effort, be ruptured. Therefore, these tests were viewed, from the standpoint of this effort, as providing data on area vulnerability and, of course, as illuminating the genuine need for investigating the survivability of fuel systems in the actual accidents.

It is interesting to note that until quite recently, accident reporting did not ordinarily include specific notation of fuel system damage. Fires, although relatively rare, (approximately 1/2 of one percent of all injury producing accidents result in fires) are usually reported because they are inherently spectacular. This small percentage of a very large number of accidents represents considerable human suffering and property damage. The fact that some recent reporting procedures call for specific fuel system damage notation and that the Bureau has a lively interest in

MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Findings and Conclusions

- Literature Search: There is little or no information in the literature indicating that tests have been performed or statistics gathered and evaluated regarding vulnerability of automotive fuel systems to damage or leakage. It is evident that interest in fuel spillage and fires in automobiles is relatively recent, but growing.
- Experimental Program: The test program indicated that barrier crashes are able to induce a variety of fuel system failures, including tearing, punctures, surge seepage, filler neck gushing, and fuel line disconnections at impact severities whose passenger compartment accelerations would, in the light of present knowledge, class them as survivable to marginally survivable. It was further shown that no present fuel system is immune to damage; that all types need improvements and that suitable test procedures must be devised to evaluate present and future systems.
- Data Analyses: The AMA and ACIR analyses produced comparable results although the data samples were somewhat different. The percentage of damaged cars which suffered fuel leaks was reported at 7.2% from the ACIR records and 8.9% from the AMA data. As might be expected, the more severe accidents produce the higher incidence of fuel system damage as well as leaks. Fuel leaks, rather than more damage, have been emphasized in this report due to their inherently great hazard.
 - Fire incidence was probably accurately reported in the AMA data; fuel system damage and leakage without fire may well have been underreported to an unknown degree, since this information was not specifically sought. Although the AMA data provide relatively little detail with regard to fuel system problems, they do confirm that fuel system failures, while most common in the more severe accidents, occur also in accidents of low and moderate severity.
- The ACIR data, which was more nearly suited to the purpose of this study, allow a number of conclusions.
 - It has been shown that a fuel system can be made to leak by a strike on any part of the car, but that the rear is over 7-1/2 times more likely to produce a leak, if struck, than is the front. The front impact, however, because it occurs in almost 70% of all accidents, produces nearly as many leaks on a numerical basis as does the rear impact. The rollover is the next most common producer of leaks, followed by impacts on the rear quarter panels.
 - The rollover seems to produce a special hazard of its own due to the somewhat higher likelihood that the occupants will be trapped; inversion of the car or door jamming caused by roof deformation may make exit more difficult.
 - While it might be assumed that a mid-tank is best from the standpoint of fuel system protection, it is apparent from this study that location alone is not the total answer. Improvements can come about only through a consideration of the entire system - fuel tank location; fuel line, electrical system and exhaust routing and surrounding structure configuration.
 - A definite need has been shown for continuing programs of data collection and statistical analyses in order to rationally establish the relative sensitivity to damage of various fuel systems. With additional accident investigations running parallel with continued development of fuel systems and appropriate testing, much of the conjecture presently being advanced relative to improved fuel systems could be eliminated.
 - It should be noted that past statistics, including those used for this study, have contained no known specific reference to cars equipped with evaporative emission control devices. These controls complicate the fuel system to a marked degree and their effect on overall fuel system integrity is open to question.
- Testing: It is apparent from this study that a comprehensive fuel system integrity testing program requires more than the frontal barrier crash that has previously been the only test specified.

- Detailed test procedures and instrumentation requirements have to be developed and confirmed by conducting actual tests. Test variables must be selected on a rational basis. The answer to some questions must come from ongoing studies in areas other than those strictly concerned with vehicle crashworthiness.
- For example: there is a fairly broad area of uncertainty regarding the values of peak and average accelerations and their durations which typically represent the limit of human endurance. In addition, it can be seen that fixing the test speed at some specific value does not guarantee the same occupant acceleration for all cars; some cars will be more rigid in certain areas than others which could well result in higher occupant accelerations and at the same time, less compartment and fuel system penetration for these cars.
- The initial selection of tests and test parameters will of necessity be a matter of engineering judgement, with the final test or tests to be selected after a program of experimental validation together with consideration of information from other sources, (for example, accident statistics and trauma studies) as it becomes available.
- The proposed impacting body for these tests is the SAE moving barrier as specified in the SAE Recommended Practice J850a. A barrier face shape is described in this standard; we suggest that the SAE activity in respect to this device be followed, but also that independent consideration be given to other shapes.
- For the early tests, it is recommended that the crash occur over a camera pit and that post-impact snubbing should stop the car within perhaps 20 feet to enhance under-the-car photography and leak detection. This requirement may later be waived if it is found to be unnecessary or detrimental to the test.
- A reasonable speed would appear to be 30 mph for both rear and rear quarter panel impacts: this is a severe test, but it appears to be justified by the high fuel system failure rate in these collision modes.
- Because of the practical difficulty of conducting reproducible vehicle rollovers, a reasonable simulation of this accident mode is proposed for development.
- The previously described group of impact tests will produce test cars with collision damage. While it is probable that one specimen will be used for each impact test, it is conceivable that one car could be used for all three. In any event, it is proposed that the previously tested specimen(s) be firmly attached to a platform which is constructed to rotate the car about its longitudinal axis. The previous damage would be assumed to be comparable to that sustained in a typical rollover and the platform would induce the roll parameters, rotation and inversion.

Recommendations

- This study has shown that no part of a car is invulnerable to collision induced fuel leaks and that rear impact, front impact, rollover and rear quarterpanel impact, in that order, produce the greatest number of fuel leaks.
- It is recommended that the 30 mph frontal fixed barrier crash as specified in FMVSS-301 be continued and used as a basis for the development of future frontal impact testing methods.
- In addition, other test methodologies are recommended for development and subsequent consideration as practical fuel system integrity tests for compliance purposes.
- Development of impact tests is recommended for the rear of the car and the rear quarter panel.

The Contract Manager has certified that the contractor's work has been satisfactorily completed and that all contractual obligations have been met.

The opinions, findings, and conclusions expressed in this summary are those of the contractor and not necessarily those of NHTSA.

Availability: This report may be ordered in paper copy (PC) or microfiche (MF) from NTIS. Order by DOT/HS-800 296 or PB-195 347.

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WASHINGTON, D.C. 20591

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X	Regional Administrator, NHTSA, Room 301, Mohawk Bldg., 222 S.W. Morrison Street, Portland, Oregon 97204, Tel: 503-226-3754. (Alaska, Idaho, Oregon, and Washington)